

# In Situ Chemical Reduction for Organic Explosives in Soil



*Proven Remediation Technologies for  
Soil, Sediment, and Groundwater*



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NDIA/Denver May 2009

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# Presentation Outline

- Project Background
- Technology Overview - DARAMEND®
- Implementation
- Results
- Degradation and Toxicity
- Summary



## Project Background

- Tooele Army Depot (TEAD, Near Salt Lake City)
- TNT Washout Facility (SWMU-10)
- 10,000 CY Soil
- TNT and RDX (up to 2500 and 1000 mg/kg)
- Exposure Pathways
- Treatment Goals
- Selected Remedy





## Project Background, cont.





## Project Background, cont.

- Project bid in 2007 by MWH
- Plexus Scientific award
- Composting cost and time
- Alternate offered, including pilot
- 2007 work





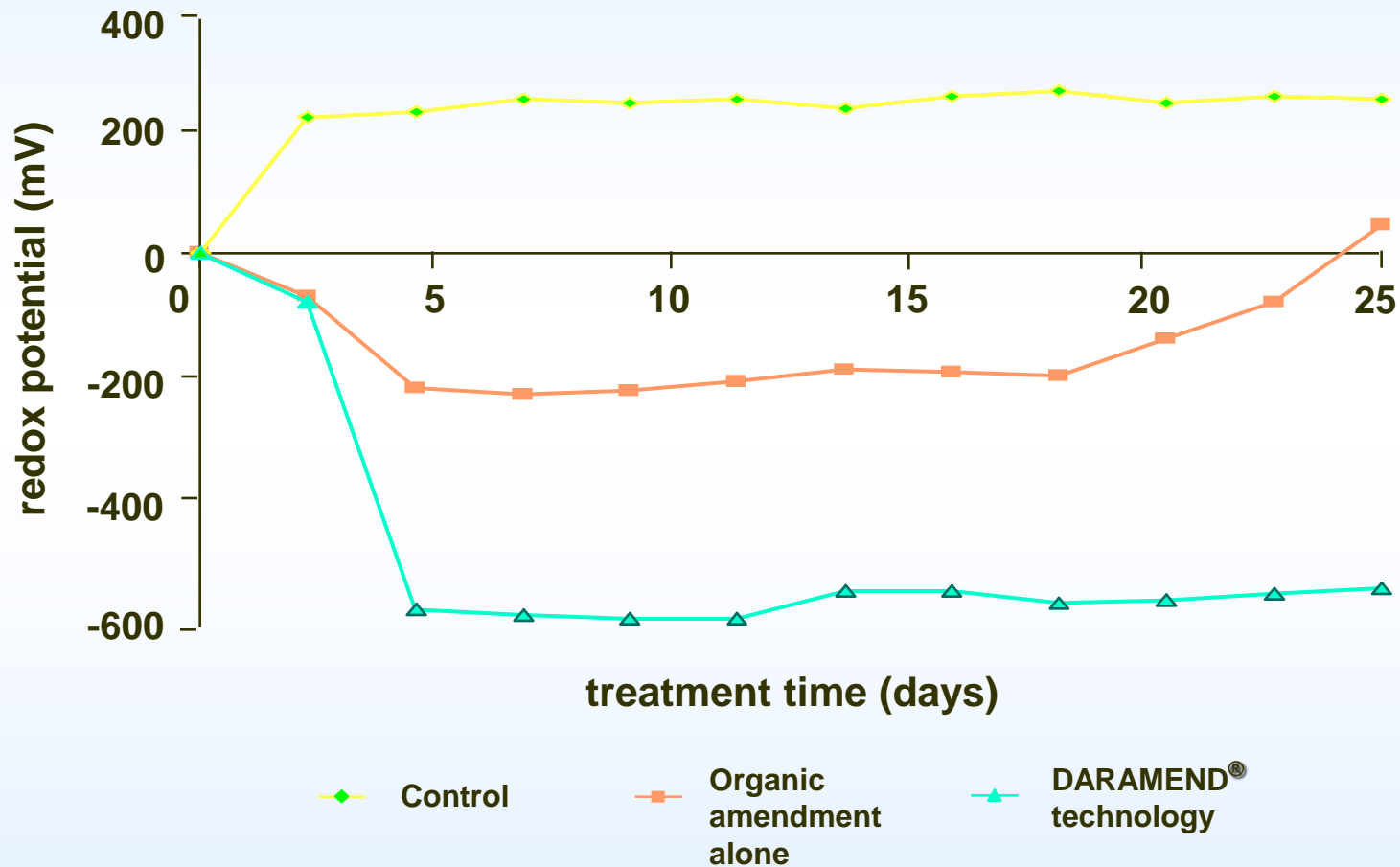
## Technology Overview - DARAMEND® Soil Amendment

- Combines solid controlled-release carbon and nutrients (aerobic) or with micro-scale ZVI (anaerobic)
- Stimulates indigenous bacteria by providing carbon and nutrients
- < 5% by weight required to treat most soils
- Treated over 5,000,000 tons of contaminated soils
- Creates ISCR Conditions





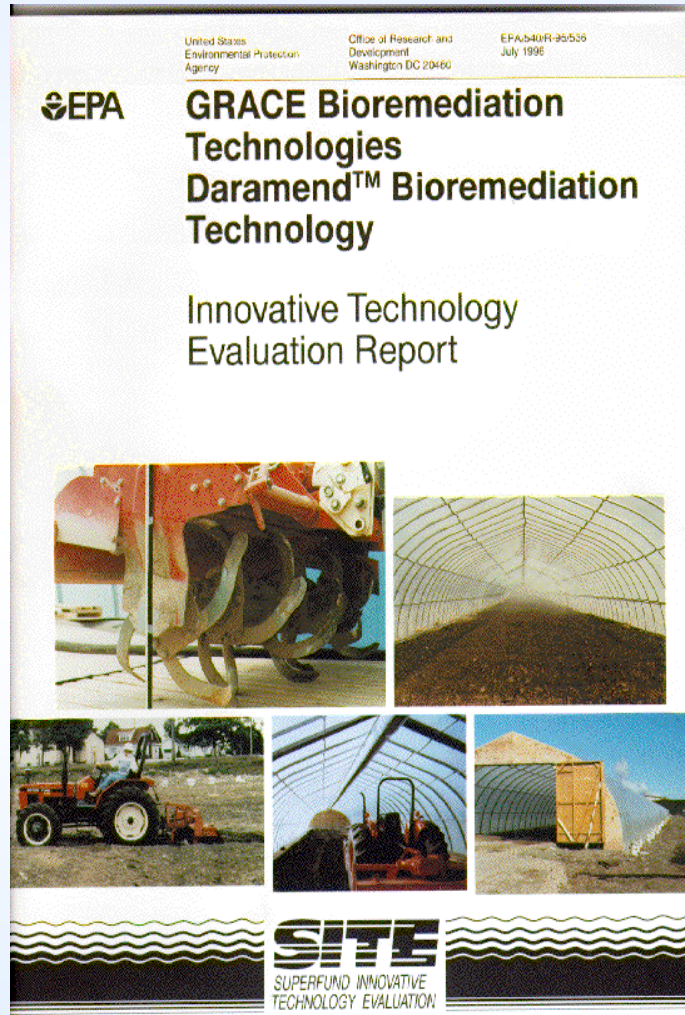
# Reductive DARAMEND® Bioremediation







# DARAMEND® Evaluation by USEPA



## U.S. EPA SITE Report

EPA/540/R-95/536





# DARAMEND® Technology Applications

## Cycled Anaerobic/Aerobic

- chlorinated pesticides and herbicides
- organic explosives
- chlorinated solvents

## Aerobic

- wood treatment chemicals (PAHs & PCP)
- manufactured gas plant PAHs
- phthalates





## DARAMEND® - For Explosives

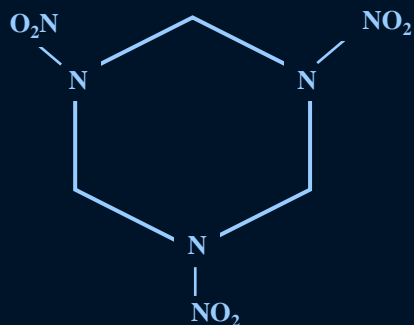
### Some Sites Treated

- U.S. Army's Raritan Arsenal - Edison, NJ
- U.S. Naval Weapons Station - Yorktown, VA
- Iowa Army Ammunition Plant - Burlington, IA
- Joliet Army Ammunition Plant - Joliet, IL
- Tooele Army Depot, Tooele, UT



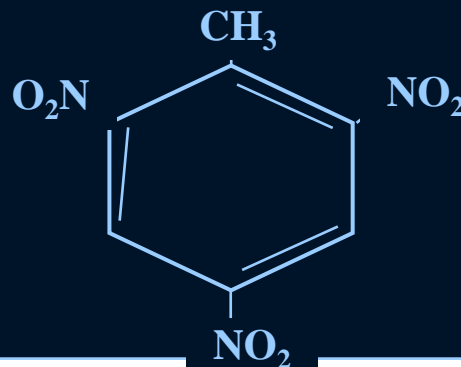
# HMX, RDX, Tetryl & TNT Explosives

1,3,5-trinitro-1,3,5-triazacyclohexane



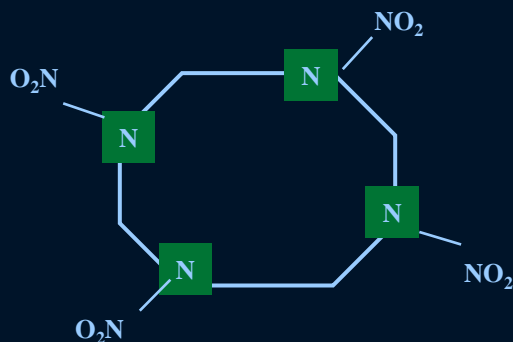
**RDX**

2,4,6-trinitrotoluene



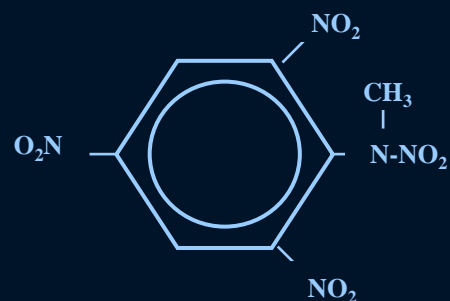
**TNT**

cyclotetramethylene tetranitramine



**HMX**

trinitro-2,4,6-phenylmethylnitramine



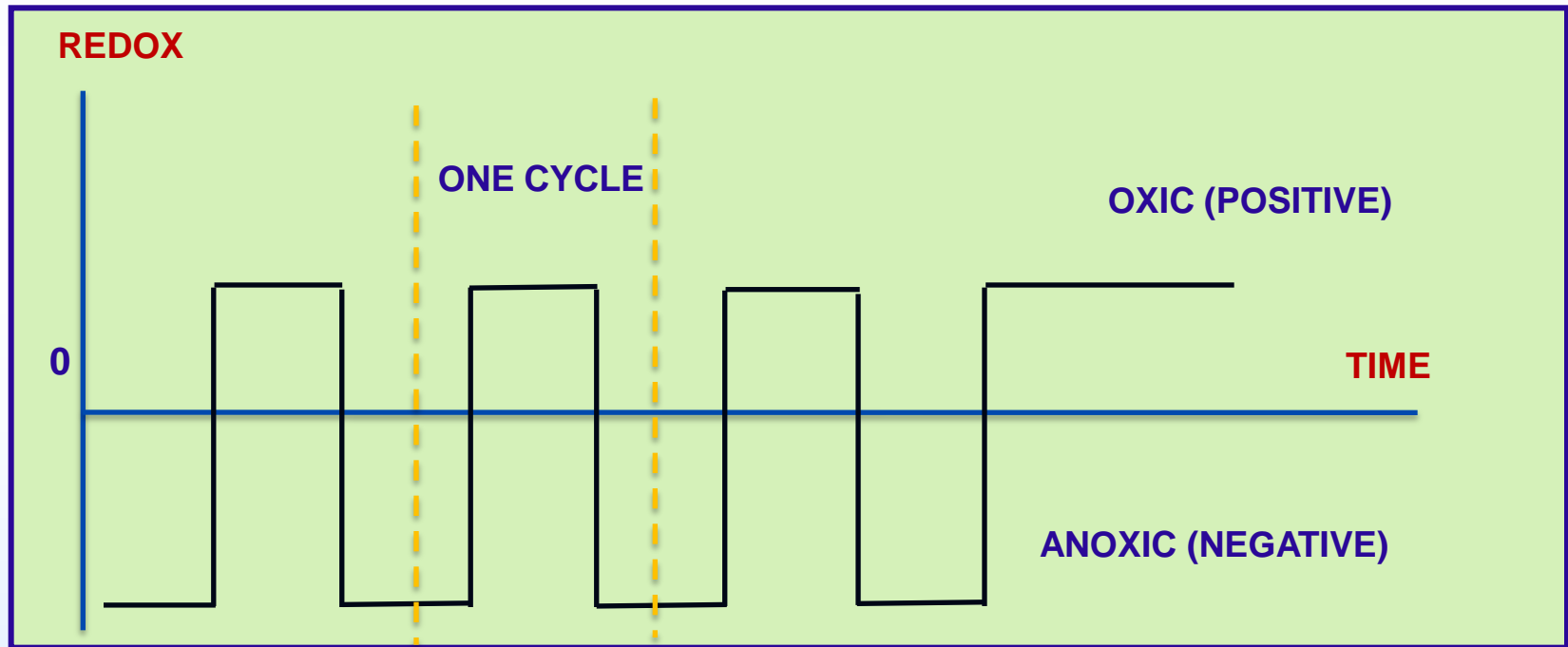
**Tetryl**





# DARAMEND<sup>®</sup> - Treatment Cycles

- Anaerobic/reductive phase
- Aerobic/oxidative phase
- Treatment optimization - site specific





# Tooele Army Ammunition Depot





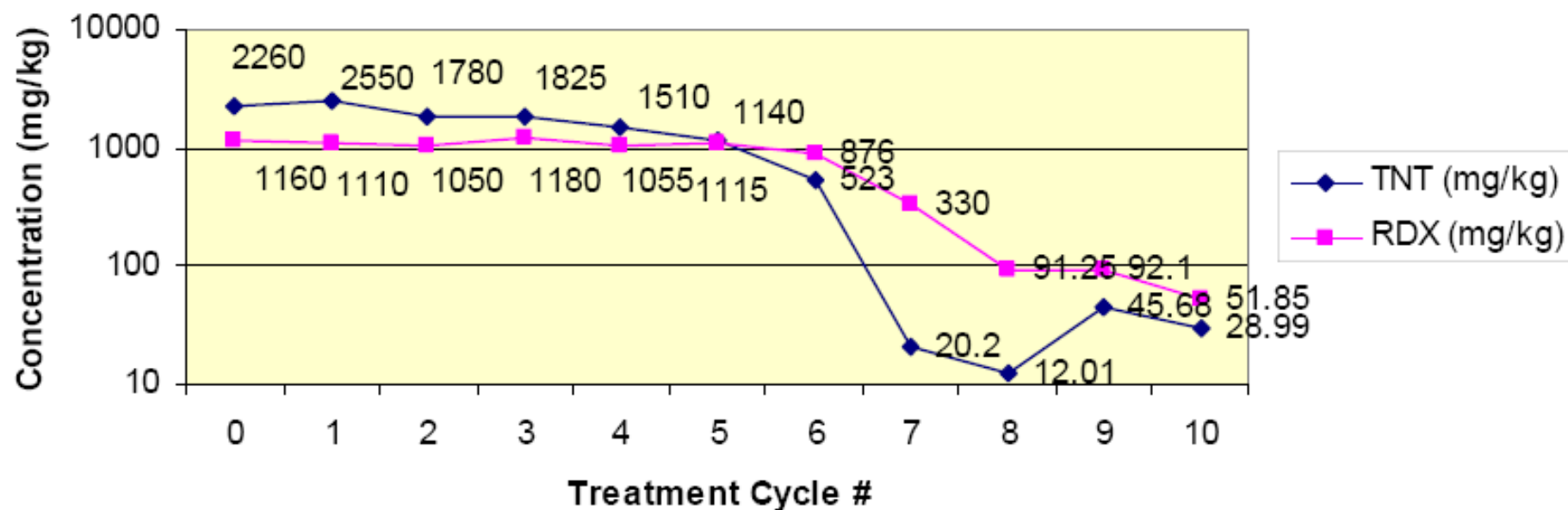
## Implementation - Pilot Study

- 7 CY Soil treated in Greenhouse (2007)
- Soils initially cool and soil relatively dry
- Increased moisture (62% -92%) and temps (13-40 C) in later cycles
- ORP from +75 at start to -550 mV at end
- Cycles typically 0.5 to 1 wt% DARAMEND



# Pilot Results

## Treatment Influence on TNT and RDX Concentrations (Averaged)







## Pilot Lessons Learned

### Primary - Process Controls:

- Maintain soil temp at 25 C or higher
- Target 90% soil WHC

### Secondary - Process Observations:

- ORP
- Odor
- Soil Consistency
- Fungus



## Implementation - Full Scale

- Conducted inside building (2008)
- ~3000 CY/batch
- 3.5 wt% DARAMEND/batch
- 8900 CY treated



# Implementation Steps

- Excavate Soil
- Place soil in building
- Add DARAMEND
- Till
- Add Water
- Create Piles



# Soil Excavation







# Soil Placement





# DARAMEND Addition







# Soil Tilling





# Water Addition







# Create Piles







# Fungus





## Full Scale Results

- All Batches Treated with one DARAMEND Addition
- Additional Declines after one cycle
- Little Process Data Collected
- Slow Water Additions (1 week)
- Product Cost \$62/CY
- 8900 CY treated
- \$4.75 million under budget
- Dosage ~5% of Conventional Composting
  - 3.5 wt % DARAMEND
  - 70 wt % Organic Matter for Compost



## First Batch Data

	<b>Treatment Goal</b>	<b>Initial*</b>	<b>Post Treatment*</b>	<b>One Week Post-Treatment**</b>
<b>RDX (PPM)</b>	<b>31</b>	563	13	6
<b>TNT (PPM)</b>	<b>86</b>	802	138	7

\* Average of six samples

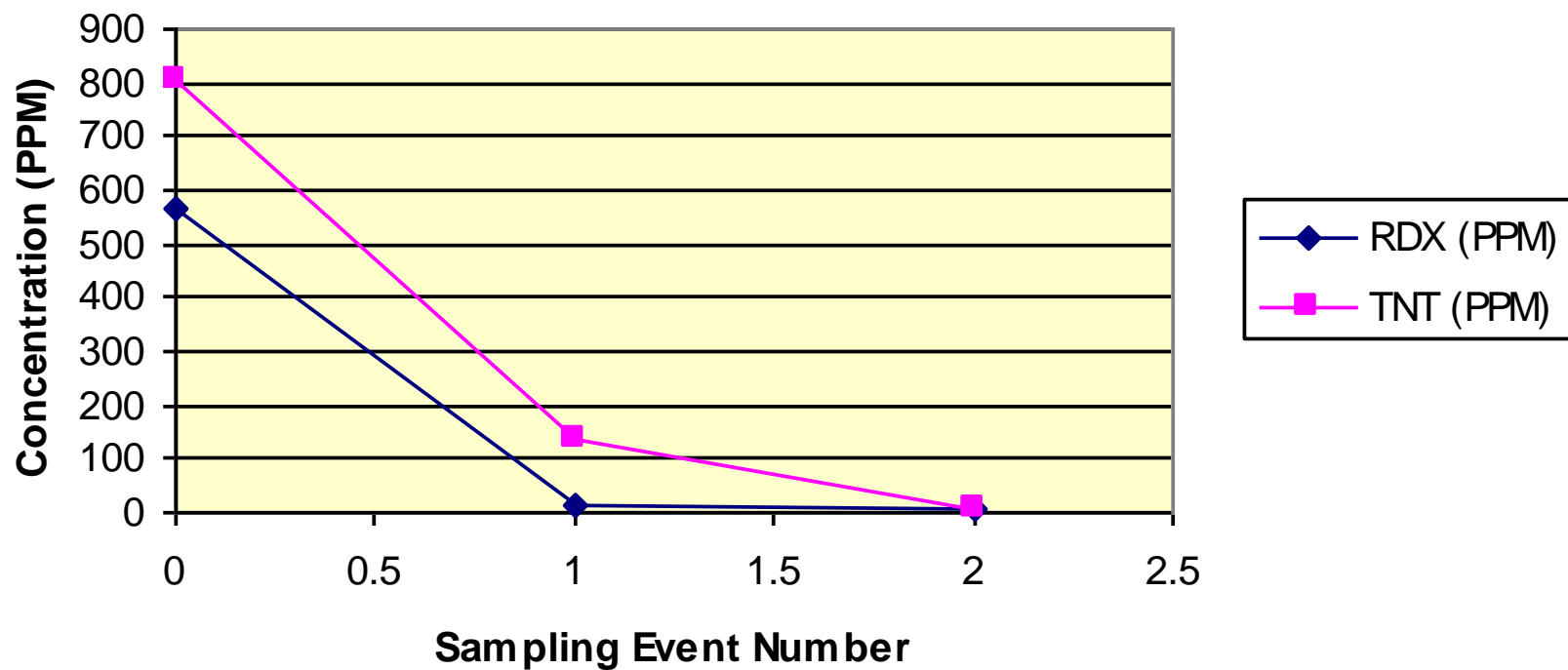
\*\* Average of three samples (re-sample of highest areas)





## First Batch Data, cont.

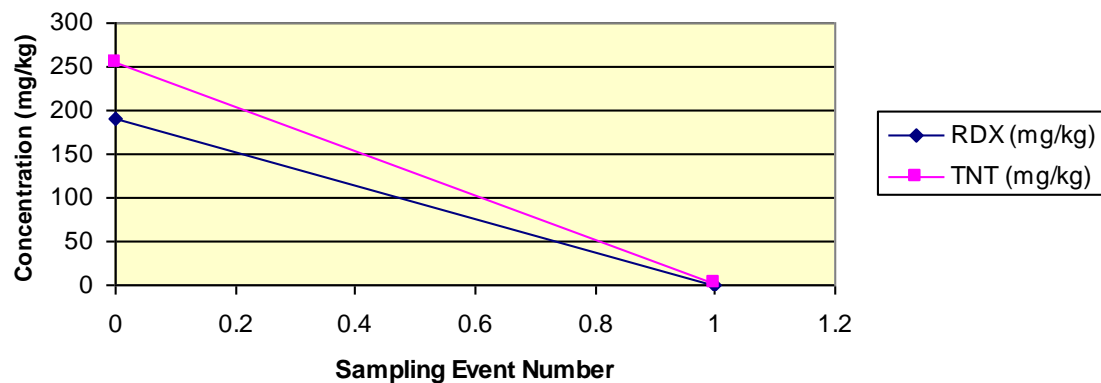
Average TNT and RDX Results



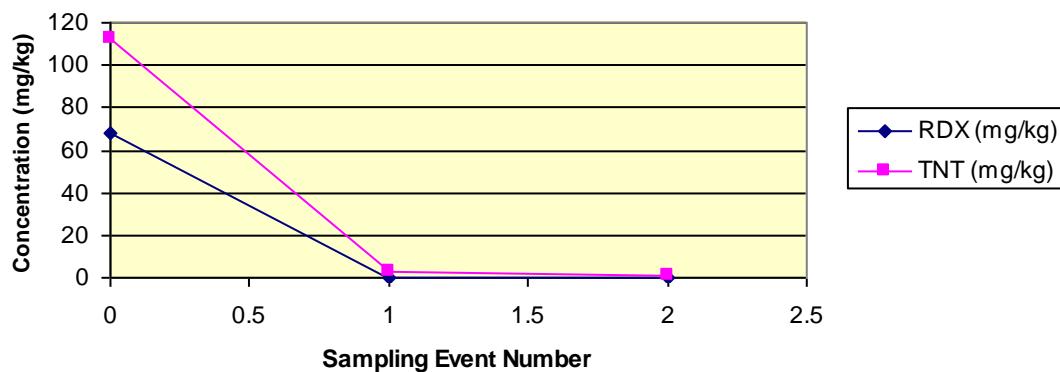


## Batch 2 and Batch 3 Results

Batch 2 - Average TNT and RDX Results



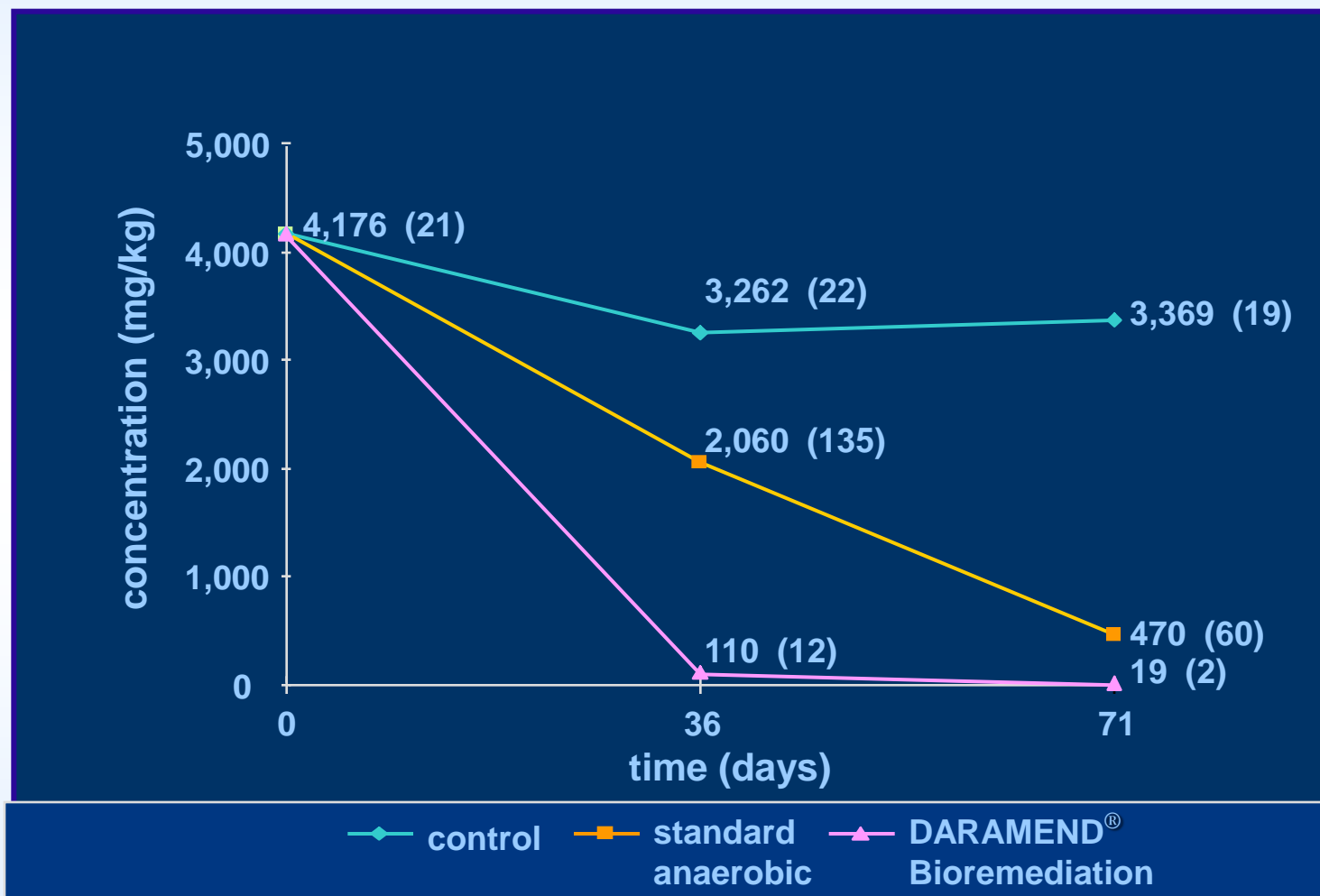
Batch 3 - Average TNT and RDX Results





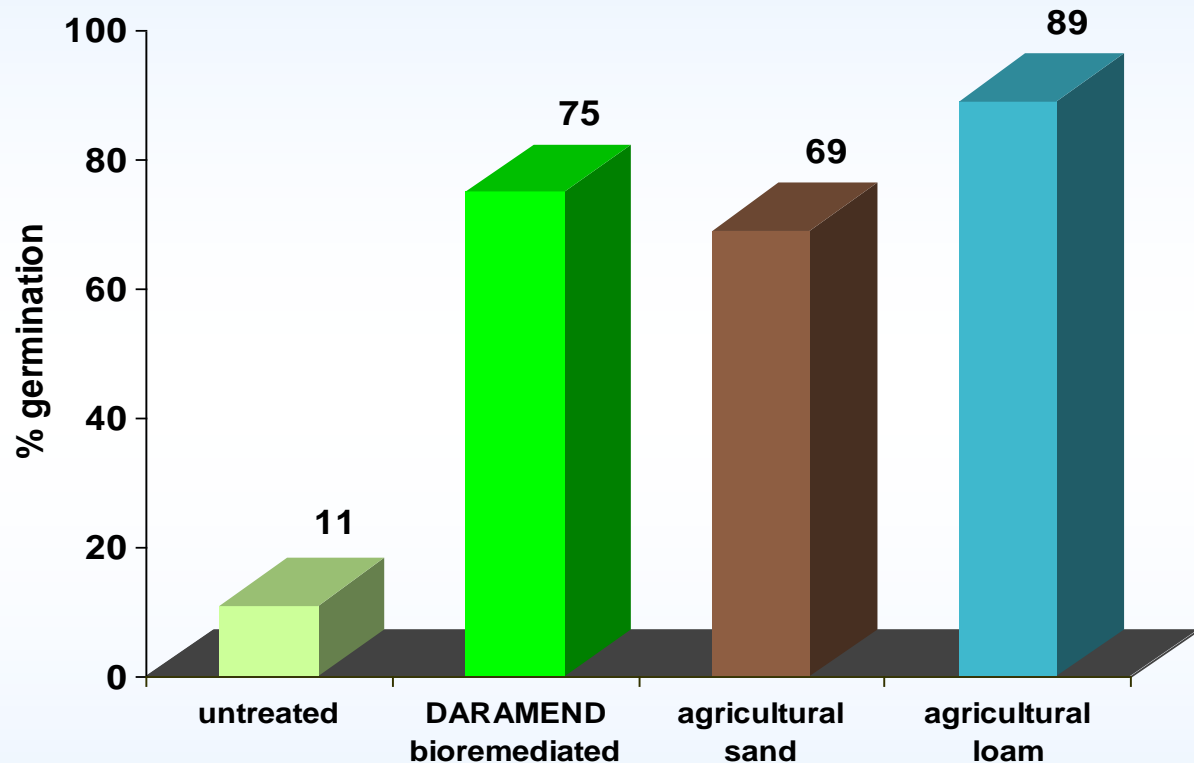
# Degradation and Toxicity

## TNT and Total Amino Compounds





## Degradation and Toxicity - Effect on Tomato Seed Germination in Organic Explosive Contaminated Soil







# Summary

- DARAMEND outperformed composting
- Remedial goals attained within reasonable timeframes
- Can be effectively utilized *Ex* or *In Situ*
- Material cost was \$62/CY treated
- Total project cost \$4.75 million under budget



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